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THIRD BI-MONTHLY REPORT

Ground Test Article for Deployable Space Structure Systems

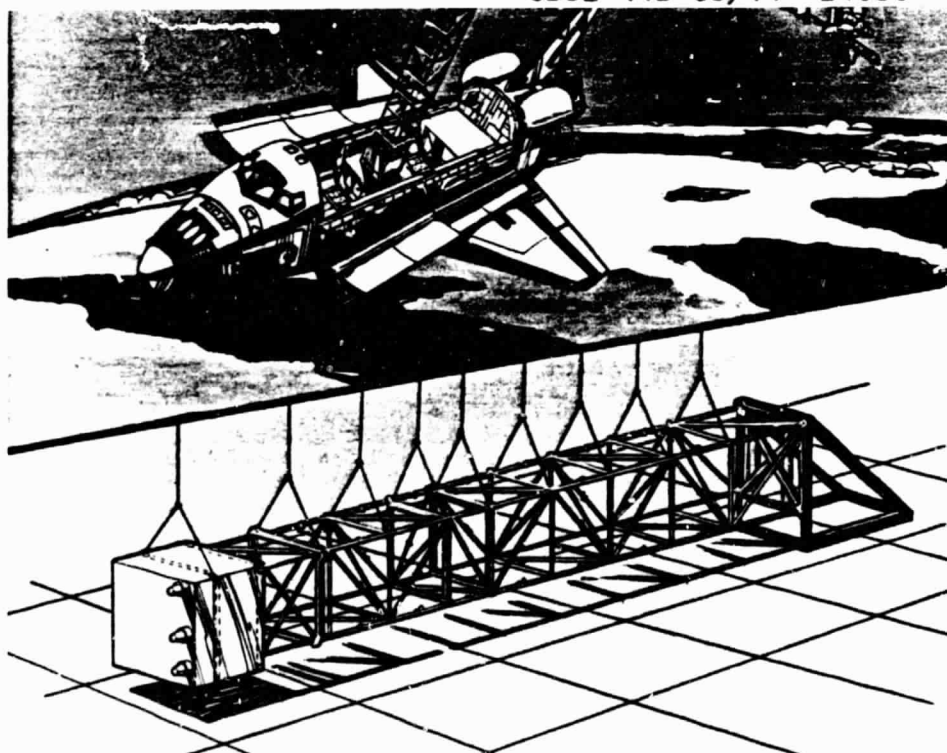
NASA / MSFC Contract NAS8-34657

September 1984

(NASA-CR-171158) GROUND TEST ARTICLE FOR
DEPLOYABLE SPACE STRUCTURE SYSTEMS
Bimonthly Progress Report (Rockwell
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Rockwell International
Space Station Systems Division

THIRD BI-MONTHLY PROGRESS REPORT
GROUND TEST ARTICLE FOR
DEPLOYABLE SPACE STRUCTURE SYSTEMS

NASA/MSFC CONTRACT NAS8-34657

SEPTEMBER 3, 1984

Prepared for

National Aeronautics and Space Administration
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By

A handwritten signature in cursive script, reading "G. D. Malloy", is written over a horizontal line.

G. D. Malloy
Project Supervisor

Space Station Systems Division



Rockwell
International

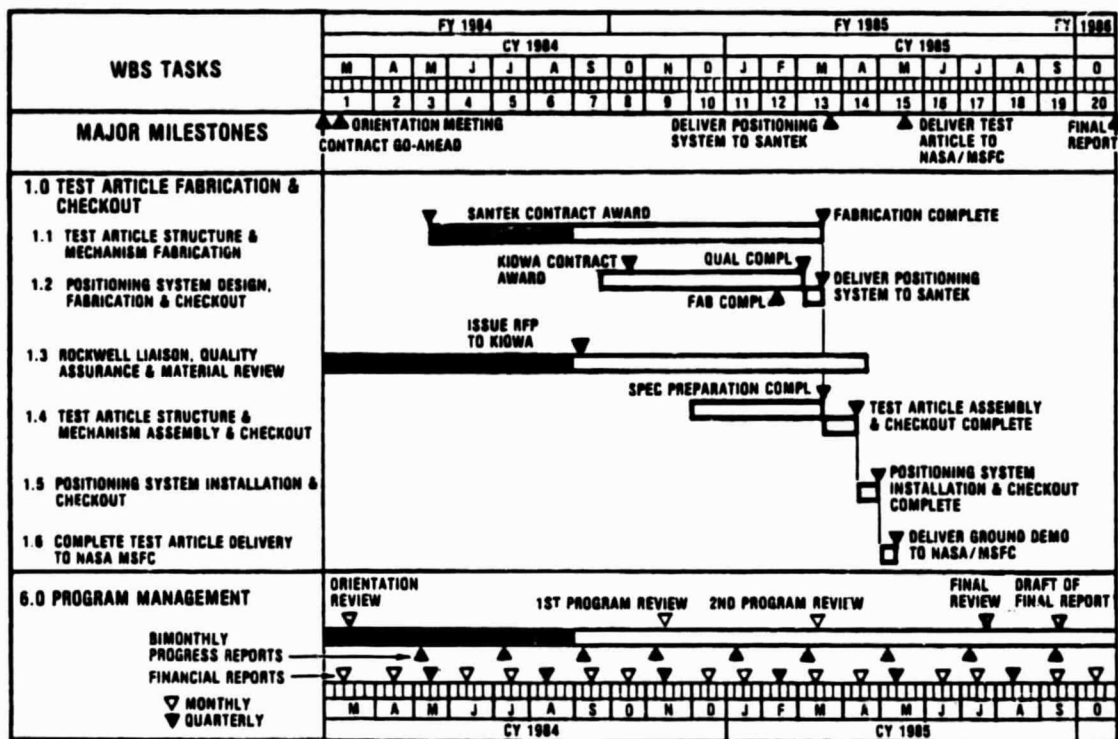
INTRODUCTION

This report is submitted in compliance with the Bi-Monthly Progress Report Requirements delineated in Attachment A of Article XVIII, Contract NAS8-34657.

PROGRESS SUMMARY

A summary of the major accomplishments during the period July 1 through August 31, 1984 is presented below.

Work is progressing in accordance with the following schedule.



The ground test article fabrication and assembly plan was completed by Santek Engineering, Inc. July 7, 1984. The plan was reviewed and accepted by Rockwell during an on-site visit to the Santek facility July 9, 1984.

Raw material and hardware orders were placed by Santek in July. Approximately 98% of the raw materials and 10% of the hardware deliveries have been completed. Several material and hardware substitutions were requested by Santek due to no-bid responses from suppliers or excessive costs for limited quantity

items. These substitutions were evaluated and approved by Rockwell Engineering and Material and Process and are being incorporated into the drawing package.

Santek started fabrication of detail parts in mid-August. Their current resource utilization is at approximately 50% of the planned eventual commitment and is increasing at a rate commensurate with the fabrication and assembly plan. At this writing, Santek's estimate of completion is 03%.

During verification testing of the diagonal member joint, in a program funded by Rockwell discretionary funds, the axial load to unlock the joint was found to increase significantly after a few cycles of operation. This was attributed to galling, poor lubrication, and locking pin geometry. A change of materials, lubricant, and modification of the pin geometry reduced the unlocking load and provided repeatability after 50 cycles of operation. This new design is being implemented into the ground test article.

An on-site visit of Santek was made by Rockwell August 21, 1984 to discuss the impact of the pending design changes and review Santek's progress.

Rockwell Engineering studies to update the positioning control system motion profile for compatibility with the earlier longeron and diagonal center joint design simplification were completed. The Statement of Work for the positioning system design, fabrication, checkout, and delivery was completed and is included in Appendix A of this report.

PLANNED WORK

The major events planned for the months of September and October include the following:

SANTEK ENGINEERING

1. Continued fabrication of detail parts.
2. Start of finish operations, final inspection, and function fit checks of detail parts and subassemblies.

ROCKWELL ACTIVITY

1. Completion of negotiations and awarding of the contract for the design and fabrication of the positioning system.
2. Continued monitoring of Santek's progress.
3. Engineering liaison in support of material review, and drawing interpretation.
4. Source inspection activities.

PROBLEM AREAS

No unresolved problems are known to exist at the present time.

FINANCIAL SUMMARY

Total cumulative costs incurred as of August 24, 1984: \$8,456.00

Estimate of cost to complete contract: \$915,977.00

Estimated percentage of physical completion of the contract: 3.6%

Percentage of completion based on the cumulative cost through the report period is 0.9%. The resultant variance of 2.7% between the physical and cost percentage of completion is considered within acceptable range of deviation.

APPENDIX A

STATEMENT OF WORK

POSITIONING SYSTEM FOR DEPLOYABLE PLATFORM SYSTEM

STATEMENT OF WORK

POSITIONING SYSTEM FOR DEPLOYABLE PLATFORM SYSTEM BUILDING BLOCK

AUGUST 17, 1984

- 1.0 The Contractor shall provide all the labor, materials, facilities, and equipment to design, fabricate, qualify, and deliver the Positioning System to Santek Engineering, Inc., Guntersville, Alabama.

Delivery shall be within five months after contract award.

Fabrication and assembly shall be controlled by a quality control system that complies with the requirements of Rockwell Specification (enclosed) STO 8026T0002, Revision J, dated November 1, 1982.

The Positioning System is comprised of three totally separate positioning systems:

1. The batten deployment/retraction positioning system
2. The longeron unlocking positioning system
3. The diagonal unlocking positioning system

The Positioning System shall satisfy the requirements specified in Enclosure A, "Positioning System Requirements". A brief description of the Deployable Platform, as pertinent to the Positioning System, is provided in Enclosure B.

The positioning system shall be capable of performing all its operating functions for a minimum of 1000 complete cycles in a two-year period from the date of delivery.

- 2.0 The Contractor shall provide the engineering personnel to install (at Santek Engineering), adjust, and achieve trouble-free operation of the Positioning System.
- 3.0 The Contractor shall provide an operations manual and the engineering personnel to instruct Rockwell personnel at the Santek facility and NASA personnel at the NASA/MSFC facility at Huntsville, Alabama on the operation of the Positioning System.
- 4.0 The positioning system shall be checked out by the contractor against simulated load profiles and/or an inertia wheel at the contractor's facility prior to shipping to the Santek facility in Guntersville, Alabama. The inertia wheel will be specified by Rockwell to simulate the mass to be moved in the actual deployment.
- 5.0 Monthly status reports of no more than two pages in length are to be submitted by the first day of each month. These reports shall be of brief narrative letter type and shall include the following:

5.0 (Continued)

A brief quantitative description of the work performed during the period and a discussion of the work to be performed during the next reporting period.

A discussion of any current problems which may impede performance and impact program schedule. Indicate what corrective action is to be taken.

In addition, the following shall be furnished:

Total cumulative costs incurred as of the report date.

Estimate of cost to complete contract.

Estimated percentage of physical completion of contract.

Statement relating the cumulative costs to the percentage of physical completion with explanation of any significant variance.

Positioning System Requirements

The Positioning System will be used to control the deployment and retraction operations to be performed in an enclosed building at the NASA/MSFC facility in Huntsville, Alabama.

Batten Deployment/Retraction Positioning System

A single motor, 1.0 minimum HP output, reversible, variable speed from 0 to 225 rpm (at the output shaft), variable torque from 0 to 250 lb-in. (at the output shaft) shall be provided to drive the four batten deployment/retraction systems used to deploy the truss. The jackscrew pitch equals 0.25 in. and the shaft diameter is 2.00 in., and has an ACME thread. A chain and sprocket assembly (furnished by Rockwell) will tie the four jackscrews together. An encoder shall be provided on the motor shaft to count revolutions and sense and transmit to the "control computer" shaft relative position. The encoder accuracy must be to 0.001 revolutions.

The control computer shall be programmable to satisfy the predetermined deployment/retraction motion profile shown in Figure 1. The positioning system shall follow the profiles to the accuracy of the encoder without overshoot. Proximity sensors will be installed on the structure by the buyer. The positioning system shall incorporate outputs of the proximity sensors for the following functions: (a) a homing profile to allow the positioning system to return to a known absolute location and (b) to incorporate controlled stop profiles to prevent damage to the structure or positioning system. The total positioning system shall be capable of attachment to a 220 volt AC power source. All electrical cabling is to be included except for the connection to the 220 volt AC source.

Longeron Unlocking Positioning System

A single motor, 0.1 minimum HP output, reversible, variable speed, from 0 to 150 rpm (at the output shaft), variable torque from 0 to 40 lb-in. (at the output shaft), shall be provided to drive the four unlocking carriage jackscrews. Each of the four unlocking carriages contain a tripping probe to unlock the four longerons. The unlocking carriage jackscrew uses an ACME thread with a pitch of 0.20 in., and has a shaft diameter of 1.0 in. Here, too, a chain and the sprocket (furnished by Rockwell) will tie the four jackscrews together. An encoder shall be provided on the motor shaft to count revolutions. The encoder accuracy must be to within 0.01 revolution, and sense and transmit to the "control computer" the shaft relative position.

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The control computer shall be programmable to satisfy the predetermined retraction motion profile shown in Figure 1. The positioning system shall follow the profiles to the accuracy of the encoder without overshoot. Proximity sensors will be installed on the structure by the buyer. The positioning system shall incorporate outputs of the proximity sensors for the following functions: (a) a homing profile to allow the positioning system to return to a known absolute location and (b) to incorporate controlled stop profiles to prevent damage to the structure or positioning system. The total positioning system shall be capable of attachment to a 220 volt AC power source. All electrical cabling is to be included except for the connection to the 220 volt AC source.

Diagonal Unlocking Positioning System

The requirements are the same as the Longeron Unlocking Positioning System.

DESCRIPTION

MAJOR COMPONENT DESCRIPTION

Figure 2 illustrates the major components of the Deployable Platform in the fully deployed configuration. Pertinent to the design of the Positioning System is the batten deployment/retraction system, and longeron and diagonal unlocking system. These three systems are described as follows:

Batten Deployment/Retraction System

This system deploys and retracts the truss by respectively moving the truss structure battens (one at a time) out of or into the main housing. The single batten motion is accomplished while the other batten, that comprises a single bay, is held stationary, thereby deploying or retracting the bay (Figure 3). To permit the foregoing, the four longerons have a folding joint in the center, and the four diagonals are designed to telescope.

The batten deployment/retraction system is comprised of four jackscrew assemblies, the jackscrew support frame, and the batten deployment/retraction positioning system. The first two of these systems is described (Figure 4) as follows:

The batten deployment/retraction jackscrew assemblies (Figure 5) consist of four jackscrews mounted at the corners of the main housing. The jackscrew, carriage, and spline assemblies are cradled within a rigid rail. The jackscrew threads and rails match similar features on the half nuts provided at the four corners of the batten (Figure 5) and carrier assemblies. Through the engagement of the jackscrews with the four half nuts, rotation of the jackscrews imparts linear motion to the battens. A splined bushing at the aft end of the two-inch diameter jackscrew (ACME thread with pitch of 0.25 in.) encircles a splined shaft that runs nearly the entire length of the jackscrew. The four splined shafts extend beyond the aft end of the rails where a chain and sprocket are attached. One of the four shafts is coupled to a drive motor (furnished as part of the positioning system) mounted on the aft end of the housing. A chain encircling the four sprockets drives all of the jackscrews simultaneously.

Encircling the rotating jackscrew is a carriage fitting which has external ears that engage matching grooves running the length of the rails. The carriage is moved forward with the jackscrew, during deployment of the first bay, until a hole in the side of the carriage engages a spring-operated pin mounted near the forward end of each rail, thereby locking the carriage.

During retraction of the final bay, the pin is manually retracted from the carriage, thus allowing the jackscrew to be retracted into the housing.

At eight places, along each rail, are adjustable spring-loaded plungers engaged in detents to offer resistance to deployment of battens stowed along the rails while a bay is being formed along the extended jackscrews. Once the bay is formed by fully extending the longeron and diagonal struts, enough force can be exerted on the restrained batten by the jackscrew to overwhelm the resistance of the plungers and thereby deploy the batten. The same procedure is repeated for deployment of each bay until the entire truss is deployed.

The jackscrew support frame assembly (Figure 4) provides lateral support to the cantilevered jackscrew ends of the four batten deployment/retraction assemblies. It contains a support frame and four telescoping diagonals that deploy and lock automatically, but are manually unlocked during retraction.

Longeron and Diagonal Unlocking Systems

The separate longeron and diagonal unlocking systems are operated only during retraction, and are respectively used to unlock the longeron and diagonal center joint latches just prior to the start of the batten retraction. Since each truss bay has four longerons and four diagonals, the longeron and diagonal unlocking systems each have four unlocking assemblies (Figures 4 and 5).

During deployment of the truss, the longeron and diagonal struts of each bay automatically snap into their fully extended positions and lock internally. During retraction, however, an external force is required to unlock the struts so that they can be subsequently folded and compressed into the truss retracted position inside the housing. The diagonal and longeron unlocking assemblies perform this function as follows: At the center of each telescoping diagonal strut and folding longeron strut is an unlocking lever and unlocking toggle pin, respectively. Lateral displacement of the pin and rotation of the lever unlock the struts, thereby permitting them to be folded or compacted to their stowed positions within the main housing. The pins and levers are remotely actuated by probes mounted on movable carriages of the unlocking systems. The carriages are installed within rails and are driven by one-inch diameter ACME threaded rods (pitch equals 0.20 in.) engaging the carriages. An unlocking system assembly is installed at each corner of the housing (Figure 4) to trip the four longeron struts of each bay. Four more are mounted near the center of each sidewall to trip the four diagonal struts of each bay. Sprockets mounted on the aft-extended end of the threaded carriage rods are interconnected by a chain encircling the sprockets. A drive motor (furnished as part of the positioning system) is attached to one of the longeron unlocking and one of the diagonal unlocking system extended threaded carriage rods. Interconnecting chains drive the three remaining carriage rods within each of the two systems.

The motor controller for each of the two systems (furnished as part of the positioning system) shall be programmed to rotate each carriage rod, thereby extending the carriage probes to engage the pin or lever on each strut,

placing them in their unlocked positions. The bay batten can then be moved toward the main housing, causing the diagonal struts to telescope and the longeron struts to fold into their fully stowed position. After the struts of the final bay are unlocked and the batten partially retracted, the motor controller shall be programmed to retract the carriages back into the housing to permit later deployment of the truss.

DESCRIPTION OF DEPLOYMENT AND RETRACTION

The following is intended to clarify the deployment and retraction sequences of the for determination of the positioning system design. Figure 1 and Drawing 42712-105 describe, respectively, the deployment/retraction motion profile and the associated deployment/retraction sequence configurations.

Deployment

The structure will be deployed vertically as shown in Figure 6 in the sequences discussed below.

1. Sequence 0 to 1. The initial configuration is shown in Sequence 0 (Drawing 42712-105). The batten deployment/retraction positioning system motor is rotated clockwise to advance the batten system jackscrews (with the carriages) to the extended position (Figure 4). At the completion of this phase, the jackscrews have advanced 49 inches in 196 ± 0.001 revolutions. The motor is stopped to permit checkout. The configuration is as shown on Drawing 42712-105, Sequence 1. Bay No. 1 is deployed and jackscrew carriage locks have been automatically engaged to lock the jackscrews longitudinally.
2. Sequence 1 to 2. The initial configuration is Sequence 1. Batten No. 1 is engaged with the jackscrews at their aft end and Batten No. 2 is on the rail constrained longitudinally by the spring plungers. The batten deployment/retraction positioning system motor is started counterclockwise, driving the adapter off the jackscrews and advancing Batten No. 1 forward. The motor continues for 196 revolutions ± 0.001 , and stops. At the conclusion, Bay No. 2 is developed; i.e., the configuration is as shown in Sequence 2, with Batten No. 1 engaged with the thread of the jackscrews at their forward end and Batten No. 2 on the rails.
3. Sequences 2 to 3, 3 to 4, and 4 to 5 are the same as Sequence 1 to 2.
4. Sequence 5 to 6 is the same as Sequence 1 to 2, except that the drive motor is driven through 148 ± 0.001 revolutions.
5. Sequences 6 to 7, 7 to 8, and 8 to 9 are the same as Sequence 1 to 2.
6. Sequence 9 to 10 is the same as Sequence 1 to 2, except that there is no aft batten. The longerons and diagonals are secured to the housing through appropriate attachment fittings mounted on each of the rails.

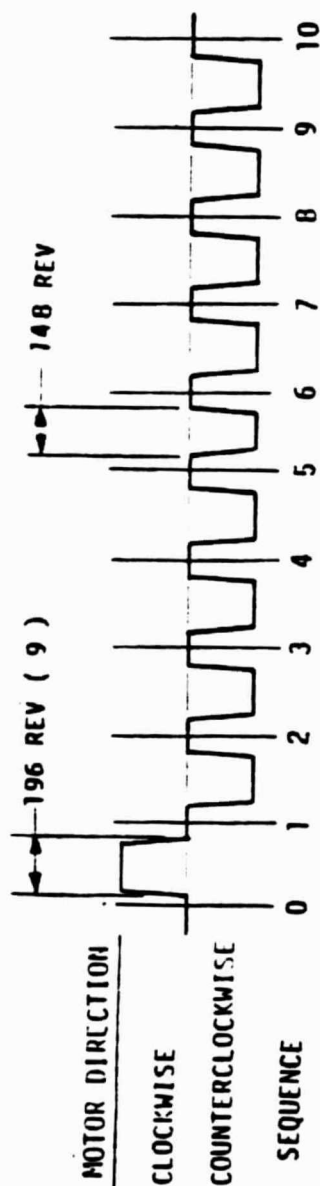
Retraction Phase

The approach to be utilized in the retraction phase is as follows. The four diagonal latches will be unlocked TBD milliseconds before the four longeron latches. The four longeron latches are released TBD seconds before the jackscrew batten deployment/retraction positioning motors are started to turn in the clockwise direction. This will be accomplished throughout all the retraction sequences unless stated otherwise.

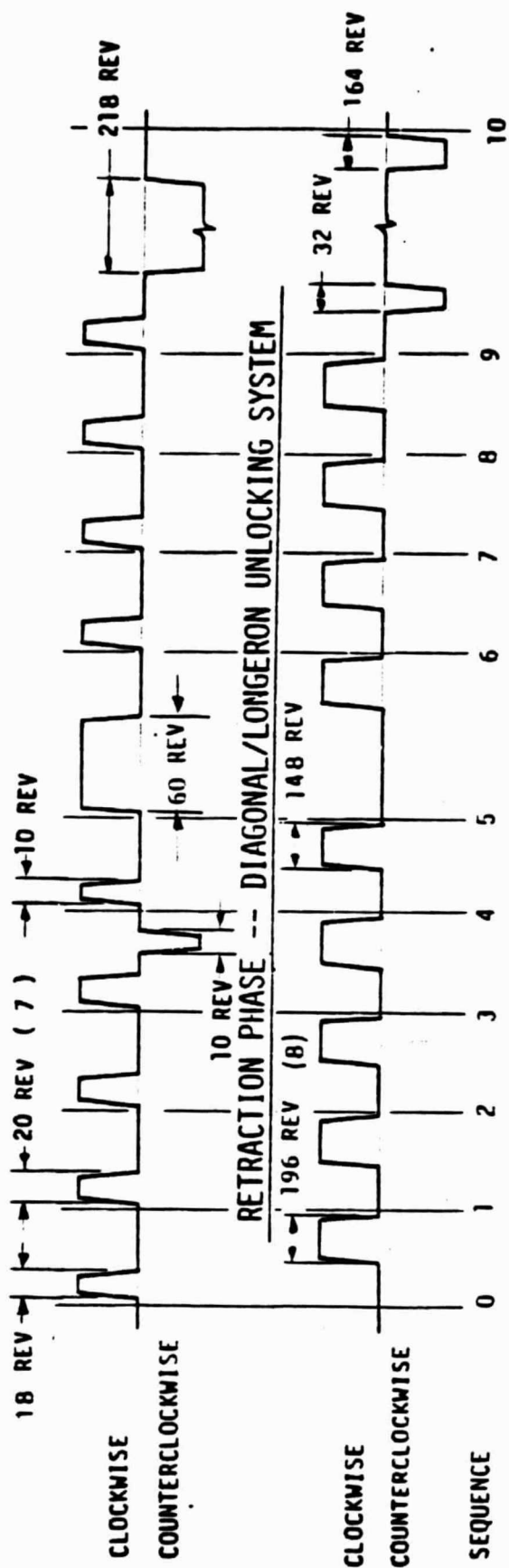
1. Sequence 0 to 1. The eight unlocking carriages are initially positioned such that the unlocking probes are approximately 2.4 inches from the diagonal trip levers and approximately 1.9 inches from the longeron tripping devices. The four diagonal and four longeron latches in Bay 10 are tripped after 18 ± 0.01 clockwise revolutions of the unlocking system jackscrews. After TBD milliseconds, the batten deployment/retraction system motors are rotated clockwise through 196 ± 0.001 revolutions, until Batten No. 9 is on the rail as shown in Sequence 1.
2. Sequences 1 to 2, and 2 to 3. Same as Sequence 0 to 1 except that the unlocking system motors are rotated 20 rather than 18 revolutions to trip the latches.
3. Sequence 3 to 4. The same as Sequence 1 to 2 except that after TBD seconds of batten retraction, the unlocking system motors are simultaneously rotated 10 revolutions counterclockwise, to be in position for unlocking the next bay. This is primarily due to the shorter length of the next bay.
4. Sequence 4 to 5. The same as Sequence 1 to 2 except for the following:
 - o The unlocking systems carriage is rotated through 10 clockwise revolutions instead of 20.
 - o The main jackscrew motors are rotated 148 ± 0.001 revolutions instead of 196 ± 0.001 revolutions.
5. Sequence 5 to 6. The same as Sequence 1 to 2 except that the unlocking system motors are rotated 60 revolutions clockwise rather than 20.
6. Sequences 6 to 7, 7 to 8, and 8 to 9. The same as Sequence 1 to 2.
7. Sequence 9 to 10. This sequence starts by rotation of the unlocking systems 20 ± 0.01 revolutions clockwise to trip the Bay No. 1 latches. The four batten system carriage locks are manually released, the jackscrew support frame locks are manually released, and the batten deployment/retraction positioning system motors are rotated through 32 counterclockwise revolutions and stopped. The unlocking system is then retracted to the stowed position by rotation of the jackscrews through 218 ± 0.01 counterclockwise revolutions. Upon completion, the batten deployment/retraction system jackscrews are rotated through 164 ± 0.001 revolutions to the stowed position.

**FIGURES REFERENCED IN
ENCLOSURES A AND B**

FIGURE 1. MOTION PROFILE

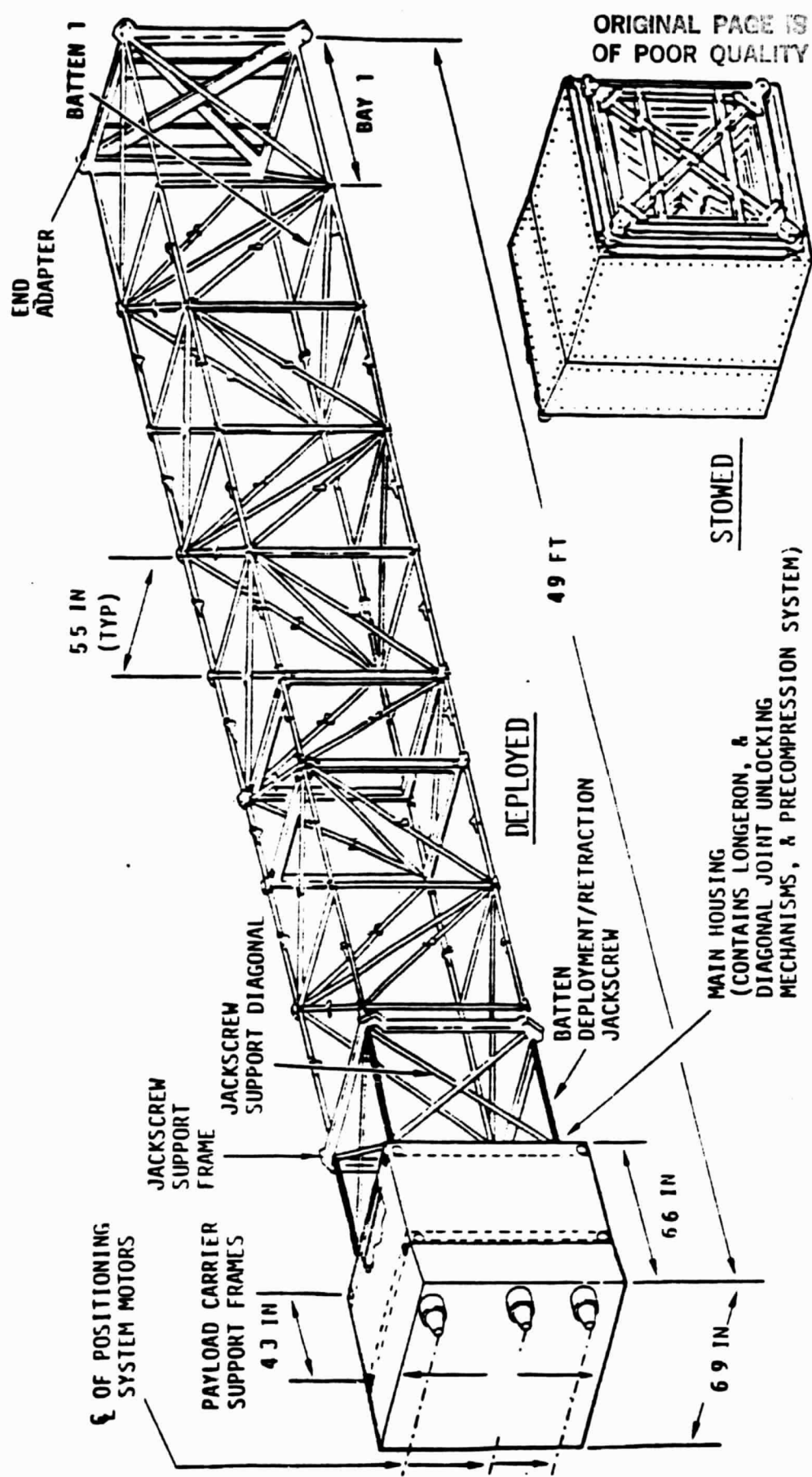


DEPLOYMENT PHASE -- BATTEN SYSTEM



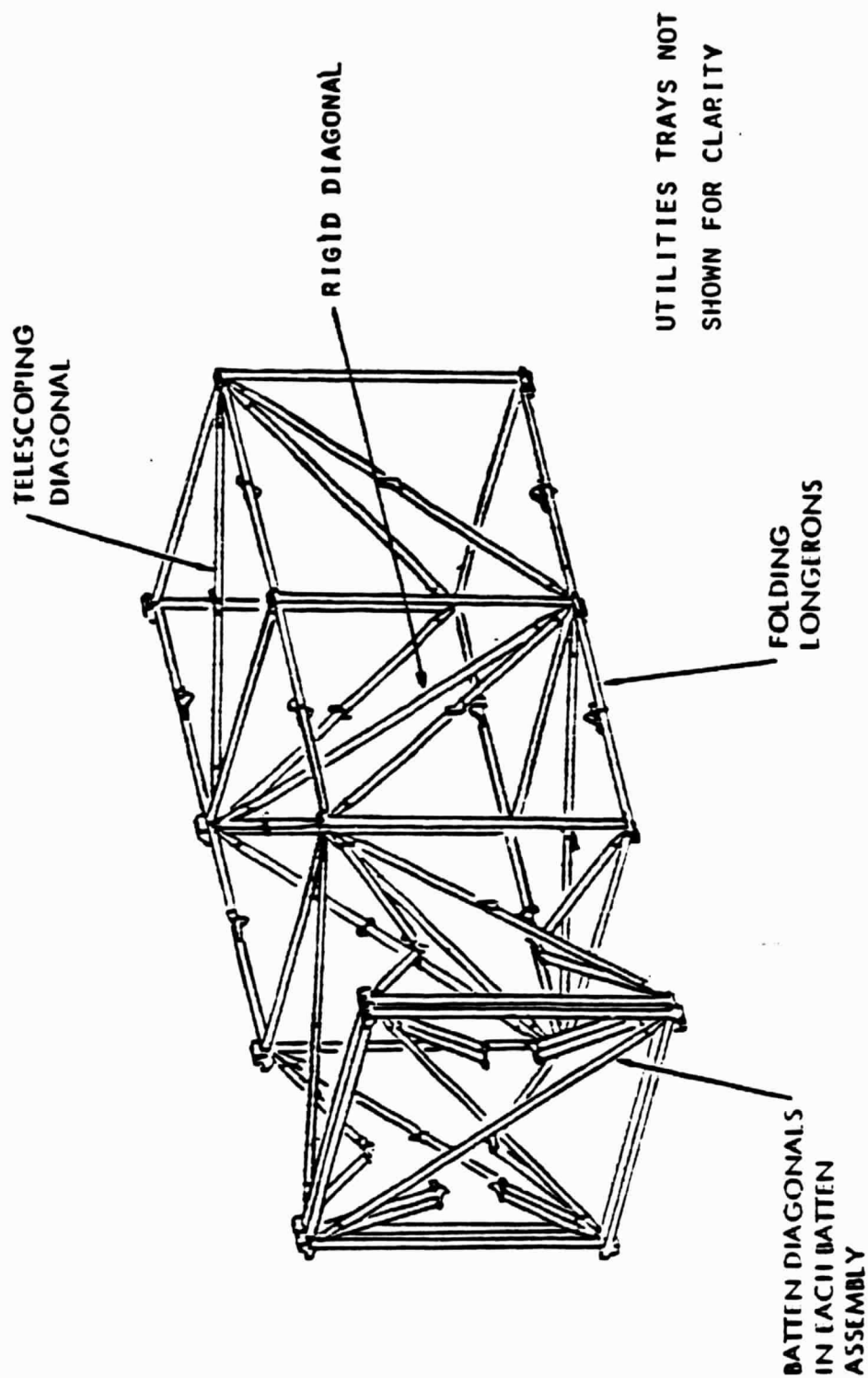
RETRACTION PHASE -- BATTEN SYSTEM

FIGURE 2. TEST ARTICLE DESIGN DESCRIPTIONS



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FIGURE 3. DEPLOYABLE TRUSS STRUCTURE DESIGN



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FIGURE 4. DEPLOYMENT/RETRACTION MECHANISM

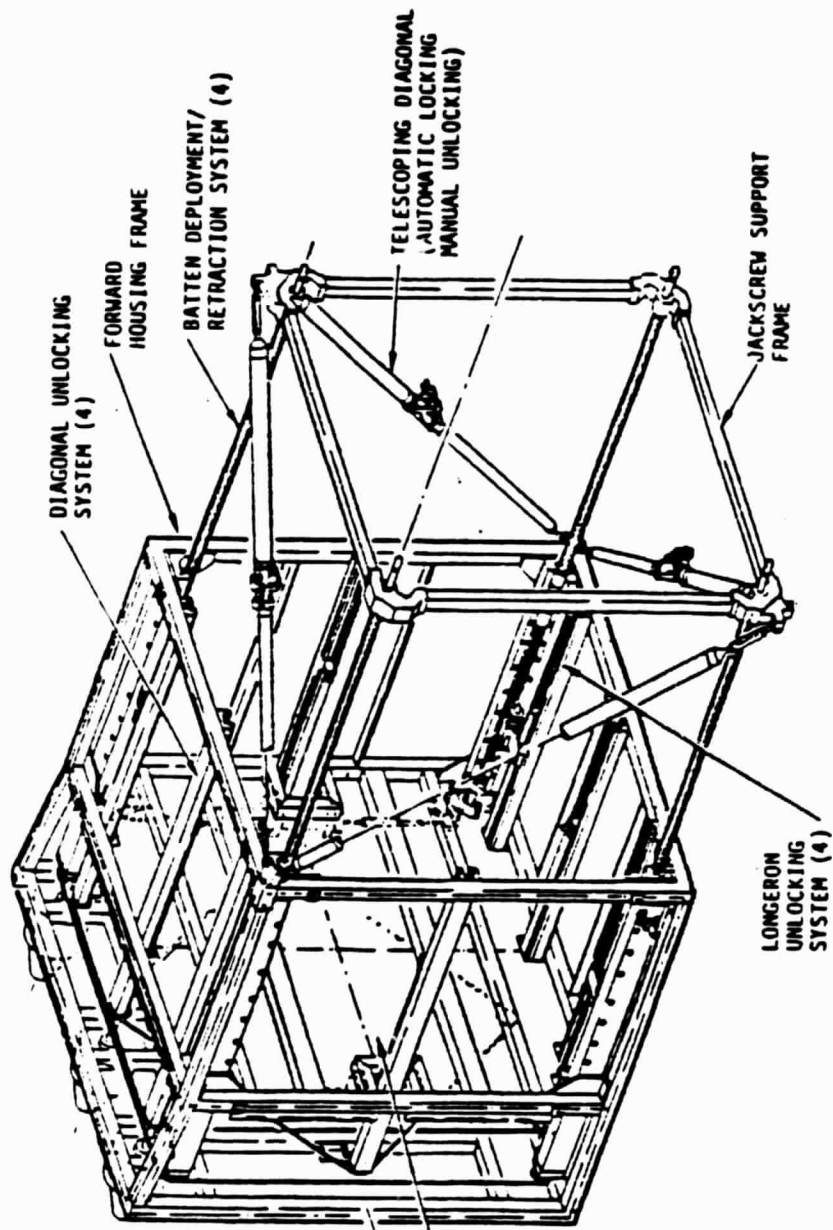
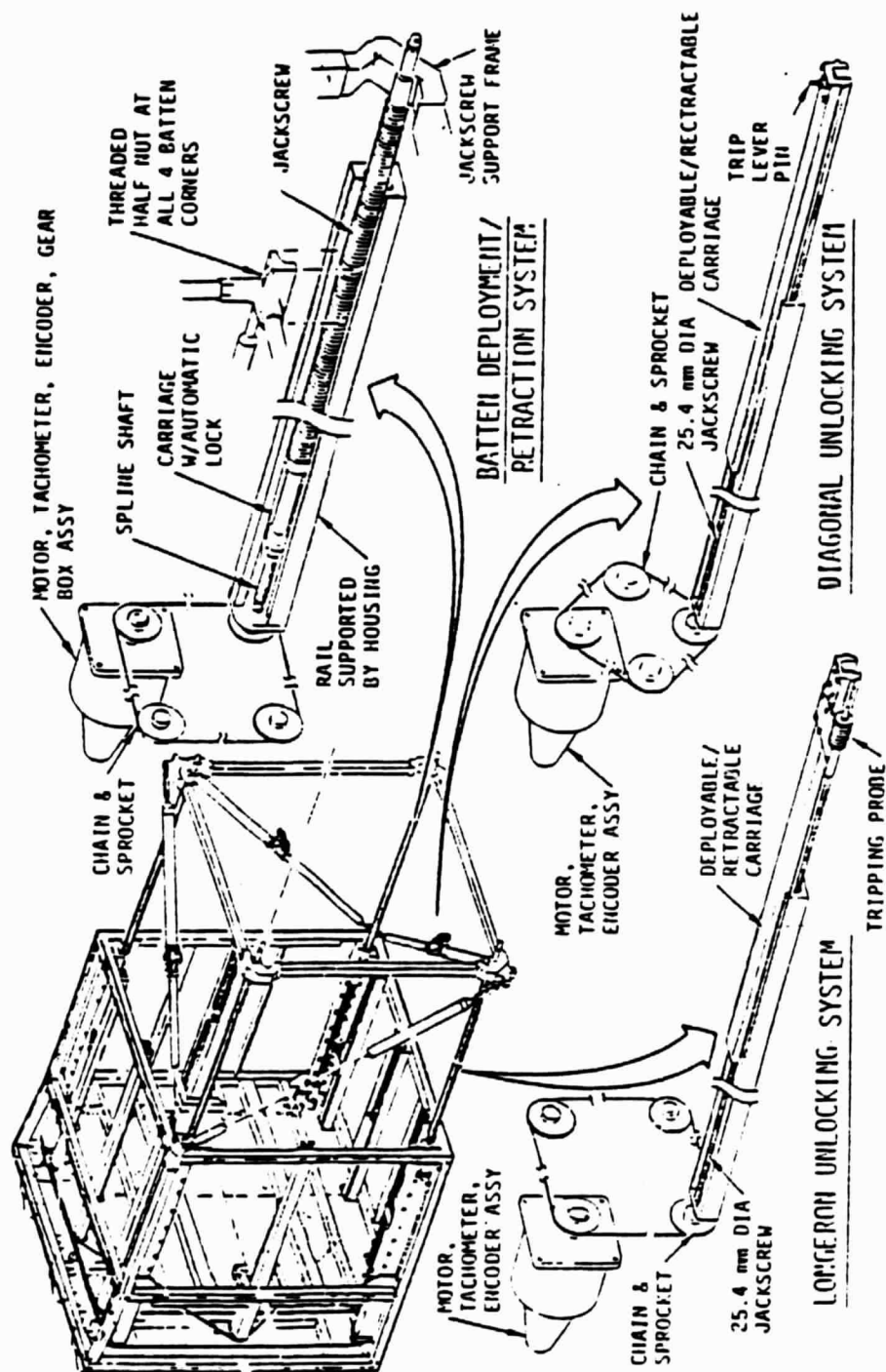


FIGURE 5. DEPLOYMENT/RETRACTION MECHANISMS—MAJOR COMPONENTS



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FIGURE 6. DEPLOYMENT/RETRACTION CONFIGURATION

